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ABSTRACT

The primary purpose of this postsecondary developmental mathematics curriculum evaluation is to assess the effectiveness of the Center for Occupational Research and Development's (CORD) Mathematics Foundations for Introductory College Mathematics. A contextually based, hands-on developmental mathematics curriculum, Mathematics Foundations is divided into two parts: Fundamentals and Algebra. Designed to enhance the mathematical skills of postsecondary developmental mathematics students, the curriculum presents mathematical concepts in the context of real-life situations, helping students gain a better understanding of the importance of math in their everyday lives. The one-semester evaluative study examined academic performance using pre- and post-tests and, using pre- and post-surveys, also examined students' and instructors' attitudes about mathematics. The study attempted to (1) gain field evaluations of the curriculum and its delivery systems; (2) obtain pertinent data on contextual learning methods within developmental mathematics programs at selected two-year colleges; and (3) help develop a national report that evaluates the pilot-site data collected, determine the effectiveness of contextual learning methods at the postsecondary level, and select exemplary model sites for longitudinal studies. Beyond the introduction and rationale of study, sections contained in the document include a review of the literature, theoretical framework, research methodology, conclusions, and research implications. (Contains 35 references.) (AS)

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Success in Postsecondary Developmental Mathematics

A Curriculum Evaluation

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Success in Postsecondary Developmental Mathematics

A Curriculum Evaluation

Sonja Lenita Graves, M.A.

Center for Occupational Research and Development

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Introduction

The Developmental Mathematics Dilemma

In postsecondary education, mathematics has served as a "gatekeeper that filters many students out of careers they might otherwise pursue" (National Research Council). Dale Parnell, former president of the Association of Community Colleges, estimated that "more than 23 million individuals in the United States cannot read, write, or compute at a functional level and many of these students turn to the community college for help." According to Parnell, colleges with an "open-door" policy are continually challenged to accommodate postsecondary students who need remediation to qualify for college-level courses.

A U.S. Department of Education report, *Remedial Education at Higher Education Institutions in Fall 1995* (compiled by the National Center for Education Statistics), says that "the percentage of freshmen enrolling in remedial (developmental) math courses increased more from 1989 to 1995 than did the percentage of freshmen enrolling in remedial reading and writing." In fact, "first-year postsecondary students were more likely to enroll in a remedial mathematics than in a remedial reading or writing class." These classes are frequently a requirement, "since fifty percent to seventy-five percent of entering community-college freshmen need remediation in mathematics in order to succeed in a college environment" (Cox).

More than ever before, postsecondary students are required to complete developmental mathematics courses prior to entering college-level mathematics courses. Unfortunately, the failure rate in such courses is alarming and unacceptable. In fact, of students enrolled in developmental mathematics courses, "fewer than one-half... are on their first attempt" (Hackett). Therefore, it is not difficult to understand why more than forty percent of mathematics courses offered in two-year community colleges are remedial (Chang).

In 1996, the Center for Occupational Research and Development (CORD) developed a two-part curriculum called *Mathematics Foundations for Introductory College Mathematics*. Book 1 of the course is titled *Fundamentals*; Book 2, *Algebra*. This curriculum is designed to address the mathematical needs of the postsecondary population by presenting abstract mathematical concepts within the context of their use. *Mathematics Foundations* is based on the theory of contextual learning, which supports the idea that mathematics can be learned best when presented within a context familiar to the student. That is, when it resonates with them through their personal experiences, jobs, family, finances, and other aspects of their lives. As Snee says, contextual learning involves "learning from your experiences by using thinking in real-life situations." To further reduce the abstract nature of some mathematical concepts, this curriculum's design contains a strong hands-on component centered around laboratory explorations.

In fall 1997, CORD conducted an initial evaluation of *Mathematics Foundations for Introductory College Mathematics*. Proven educational evaluation techniques were used to "plan, improve, and justify (or not justify) educational procedures, programs, and/or products" (McMillian and Schumacher). The evaluation was conducted in eleven community colleges and one technical college in the states of Florida, Illinois, Maine, New York, and Texas. This report describes the preliminary findings of the evaluation, the purpose of which was to examine the effectiveness of the curriculum and to analyze the attitudes – of both students and instructors – that resulted from the use of a contextually based teaching/learning strategy.

Participating colleges were selected based on responses to a pilot-site proposal that indicated their desire to implement a new technique for teaching developmental mathematics. The instructors at each pilot site attended a professional development workshop in which they experienced hands-on teaching strategies and examined the methodology for contextual problem solving.

During the evaluation, pre- and posttests were administered to students. Likewise, pre- and postsurveys were administered to students and instructors. In addition, instructors were given the opportunity to communicate with a CORD trainer and with each other via Internet E-mail on a listserv, or by telephone.

The overall results of the evaluation indicated an increase in students' academic performance in mathematics. Responses also indicated an improvement in both students' and instructors' attitudes about learning and teaching mathematics using real-life applications. This was demonstrated by their increased confidence and decreased frustration. The study indicated a need for extended longitudinal studies, which are currently in progress. The preliminary results in this report are encouraging and justify further evaluation and controlled research studies.

Rationale of Study

The primary purpose of this study is to evaluate the effectiveness of CORD *Mathematics Foundations for Introductory College Mathematics*, a contextually based, hands-on developmental mathematics curriculum. Designed to enhance the mathematical skills of postsecondary developmental mathematics students, the curriculum presents mathematical concepts in the context of real-life situations, helping students gain a better understanding of the relevance of mathematics to their everyday lives.

An objective-oriented (McMillian and Schumacher) educational evaluation design was chosen to determine the effectiveness of the curriculum. Objective-oriented evaluation is, according to McMillian and Schumacher, a method that determines the "degree to which the objectives of a practice are attained by the target group, i.e., students, teachers." This method

is an appropriate choice for measuring the outcomes of the teaching and learning practices in the developmental mathematics curriculum.

The one-semester study examined academic performance using pre- and posttests and, using pre- and postsurveys, also examined students' and instructors' attitudes about learning and teaching mathematics. The study attempted to answer the following evaluation questions:

1. Can students achieve increased academic performance by using *Mathematics Foundations*?
2. How does the *Mathematics Foundations* curriculum influence the attitudes of students and their instructors?

In addition, the study was designed to accomplish the following goals:

- Gain field evaluations of the curriculum and its delivery systems;
- Obtain pertinent data on contextual learning methods within developmental mathematics programs at selected two-year colleges;
- Develop a national report that evaluates the pilot-site data collected, determine the effectiveness of contextual learning methods at the postsecondary level, and select exemplary model sites for longitudinal studies.

The selection of pilot sites to evaluate the curriculum was limited to those using facilitative teaching techniques and innovative content delivery methods.

Review of the Literature

Developmental mathematics has become of great concern in postsecondary education because there is evidence of an increasing need for such course offerings in community colleges. Considering the fact that developmental mathematics courses are the fastest-growing area in postsecondary institutions, little is known about their effectiveness (McCornak). According to Robert Hackworth, author of *Focus on a New Idea for College Algebra*, "there is little or no formal research on the subject of the remedial mathematics student, and ... the field [is] wide open."

Although various studies have examined the problem of postsecondary remediation, one method that has received only modest attention is students' attitudes and beliefs about mathematics and about themselves as learners of mathematics (Stage and Kloosterman, 1995). Cox determined that failure in mathematics might be reflected in the attitude of students to mathematics. "Years of failure and poor grades in mathematics have... caused students apprehension regarding mathematics, and perhaps have given students a low self-esteem in this subject" (Cox).

A significant amount of research supports the premise that attitudes and beliefs influence the behavior of students, and this appears to have a substantial impact on their academic

performance. However, even with this data, research on the attitudes and beliefs of remedial college-level students is limited (Stage and Kloosterman, 1991). "We now know that success in learning will cause a favorable attitude and a favorable attitude leads to achievement and vice versa" (Cox; Wambach). Therefore, student perceptions of their ability to learn mathematics may be a critical element in enabling them to "survive" mathematics courses that are both "emotionally and cognitively difficult" (Stage and Kloosterman, 1995). But little is known about the effectiveness of remediation, especially when the failure or success of remedial students is related to their attitude or feelings about their own personal ability to succeed (Tinto, 1987b). Joyce and Weil concluded that, as "deficiencies in mathematics are corrected, the attitude of students will improve and this is related to their achievement in mathematics courses."

A study conducted at Brookdale Community College found that, as attitude scores rose, passing rates increased dramatically in remedial mathematics (Cox). Another study of 513 developmental mathematics students in eight Illinois community colleges found "attitude toward mathematics was a determinant of success or failure in remedial mathematics courses" (Elderveld). Even after two or three years of college preparatory mathematics courses, many students leave school with only a superficial, mechanical knowledge of mathematics, and are frustrated in their lack of ability to understand and apply it in any real situation. Yet, as a rule, the typical college remedial mathematics course presents students with the same format for learning mathematics that they experienced in their precollege schooling. If students had difficulty in gaining anything more than a superficial, mechanical knowledge of mathematics under these conditions in high school, why would one assume that they would fare any better under the same conditions in college?

Aware of this situation, the CORD study attempted to identify sources of success in remedial mathematics by examining the attitudes of postsecondary remedial mathematics students and the ways they relate to academic achievement.

Characteristics of Remedial Mathematics Students

Remedial mathematics students are likely to have multiple problems, of which only one is a lack of mathematical skill. In general, these students are less prepared for college than are their counterparts – the traditional, nonremedial students who successfully pass college entrance assessments. The remedial mathematics students tend to have one or more of the following characteristics (Austin; Lazdowski; Tinto1987b; Zwerling):

1. Lack of academic skills
2. Poor attitude
3. Lack of counseling
4. Lack of college survival skills
5. Low career aspirations

6. Cognitive incompetencies
7. Limited vision
8. Lack of maturity
9. Low income

Unfortunately, most remedial mathematics courses focus only on the first item on the list. This study of *Mathematics Foundations for Introductory College Mathematics*, however, directs attention to both the first and second items, and contends that a contextual approach to remedial mathematics will encourage an attitude of success, which will result in improved academic performance.

Theoretical Framework

A collection of research exists on the factors that influence self-efficacy among remedial mathematics students; however, little is known about what students feel when they experience successful outcomes in remedial mathematics courses. "Self-efficacy" was introduced by Albert Bandura, a social theorist, in the context of his social learning theory (later renamed "social cognitive theory"), and it has since become an important construct linking self-judgment to academic achievement. Bandura (1982) defines self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has, but with judgments of what one can do with whatever skills one possesses." According to Bandura, "the efficacy judgments that are the most functional are probably those that slightly exceed what one can do at any given time," and thus allow a person to develop to her or his fullest potential.

This study used the theory of self-efficacy as a lens to identify characteristics that may influence the attitudes and academic achievement of remedial mathematics students who positively judge their abilities to learn and use mathematics in a course that incorporates contextual, hands-on learning concepts. More specifically, the study sought to discover what occurs when students experience increased self-efficacy in mathematics and how this increased self-efficacy affects mathematical performance.

Research Methodology

Data-Collection Procedures

The data for this evaluative study were collected in three ways. First, each student was asked to answer as many questions as possible on both a pre- and posttest (Campbell and Stanley). Second, both students and instructors completed pre- and postsurveys in which they described attitudes and experiences related to mathematics and the hands-on contextual

approach used in *Mathematics Foundations*. Surveys such as these are considered legitimate measuring instruments to "describe the incidence, frequency, and distribution of characteristics" of the students in this study (McMillan and Schumacher). The third data collection method was by personal interviews with teachers via Internet E-mail or telephone. This allowed instructors to verbally express their experiences. Their comments are listed in this report without evaluation.

The pilot evaluation was conducted at eleven community colleges and one technical college in the states of Florida, Illinois, Maine, New York, and Texas. It included 571 students and fifteen instructors, of whom thirteen were full-time and two were adjunct instructors. According to the survey data, full-time instructors averaged thirteen years of experience in teaching developmental mathematics. One adjunct instructor had taught developmental mathematics for eight years, the other for less than one year.

Participating schools were required to:

- Offer two developmental mathematics courses using the *Mathematics Foundations* text;
- Make the necessary textbooks available for student purchase at the campus bookstore;
- Administer evaluation instruments, including pre- and posttests and pre- and postsurveys; and
- Send faculty members who participated in the evaluation to a professional development workshop to learn teaching strategies with the CORD *Mathematics Foundations for Introductory College Mathematics* curriculum.

The two-day professional development workshop was designed to prepare postsecondary mathematics instructors for their new roles as facilitators of learning rather than lecturers. The participants learned the philosophy underlying contextual, hands-on learning and experienced the techniques they would use in the classroom when implementing *Mathematics Foundations*. As a result of the training, instructors learned to facilitate hands-on, real-world lab activities and to use innovative teaching strategies to help students develop critical-thinking skills and problem-solving techniques. These teaching strategies accommodate different learning styles, promote cooperative learning, and encourage peer support.

The college developmental mathematics students participating in the study were selected by simple random sampling (Ravid). This procedure ensures that each person participating in the study has an "equal and independent" chance of being selected (Ravid). Students were assigned to classes by the college without the knowledge or control of the evaluators or the teachers, and were therefore likely to represent an unbiased sample. Students were assigned to one of sixteen class sections that included ten sections using *Mathematics Foundations, Book 1 (Fundamentals)* and six sections using *Mathematics Foundations, Book 2 (Algebra)*. The One-Group Pretest-Posttest design (Campbell and Stanley) was used to measure

academic achievement. Students were administered pre- and posttests in both the fundamental mathematics and algebra courses. The tests were designed to coordinate with the mathematical concepts presented in the texts. The questions emphasized problem solving in real-life situations.

Pre- and postsurveys were administered to students and instructors to identify their attitudes about learning and teaching mathematics. The surveys were then interpreted to determine how students and instructors felt about their experiences in mathematics prior to and upon completing *Mathematics Foundations*. Survey questions were structured on a five-point Likert scale (McMillan and Schumacher). The answer selection consisted of "always," "majority of the time," "sometimes," "rarely," and "never." Students were also asked to rank other answers on a Likert scale with values of 1 = strongly agree, 2 = agree, 3 = uncertain, 4 = disagree, 5 = strongly disagree. To allow respondents to express their personal opinions, some open-ended questions were provided. Surveys and tests were administered in a normal classroom environment. The results of this study are comprised of data collected from both the fundamental and the algebra pretest and posttest scores. Data were also collected from students' and instructors' pre- and postsurvey responses and the Internet listserv. The duration of the course was one semester, or approximately three and one-half months.

Data Analysis and Discussion

This section will discuss preliminary findings of the evaluations conducted in the following four sections: pre- and posttests scores, student pre- and postsurveys, instructor pre- and postsurveys, and personal conversations with instructors via the Internet or by phone. Of the 571 students who participated in the study, 398 completed evaluation materials in the fundamentals section, and 173 completed evaluation materials in the algebra section. Pre- and postsurveys were received from the entire sample of instructors.

Pretest and Posttest Results

The test instruments were developed by CORD. The pre- and posttest on fundamentals consisted of forty-two multiple-choice questions, while the algebra pre- and posttest consisted of sixty-two multiple-choice questions. Students were allowed one hour to work on the tests, and instructors were asked to encourage students to complete only the problems they understood, bypassing the problems they did not understand. Test scores were recorded by computing the total number of correct answers. The pre- and posttest data were analyzed using *GBSTAT*, a statistical computer program.

According to the data collected, the mean scores posttests were higher than the mean scores of the pretests for students in both the fundamentals and the algebra classes.

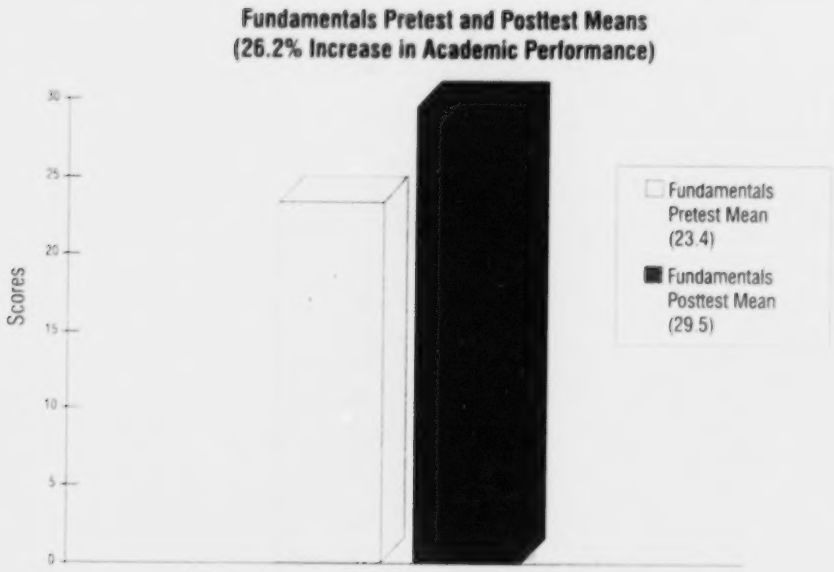

Figure 1a

Figure 1a illustrates the combined pre- and posttest results from all fundamentals sections. The mean score on the fundamental mathematics pretest was 23.4. The comparable score on the posttest was 29.5. This is an increase of 26.2 percent (26.2%) in scores on the fundamental mathematics tests. A t-test (Crowl) was performed resulting in a p-value of less than 0.01 ($p<0.01$). The alpha level was set at 0.05. This substantiates the fact that those students taking the fundamentals course made significant progress in academic performance.

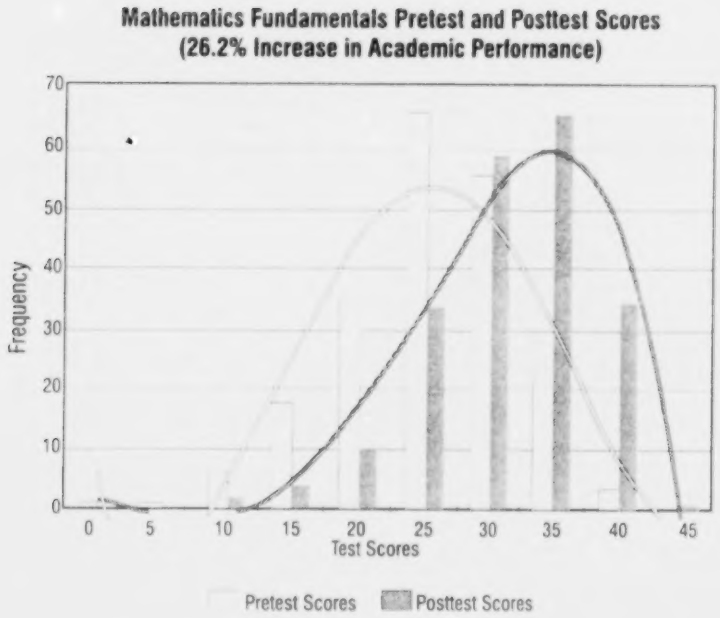

Figure 1b

The data plots and curves in Figure 1b give the distribution of scores. The pretest shows a near-normal distribution, while the posttest distribution is skewed to the left. These results may imply that a larger proportion of students demonstrated increased academic performance while some remained at a very low achievement level after completing the developmental mathematics course.

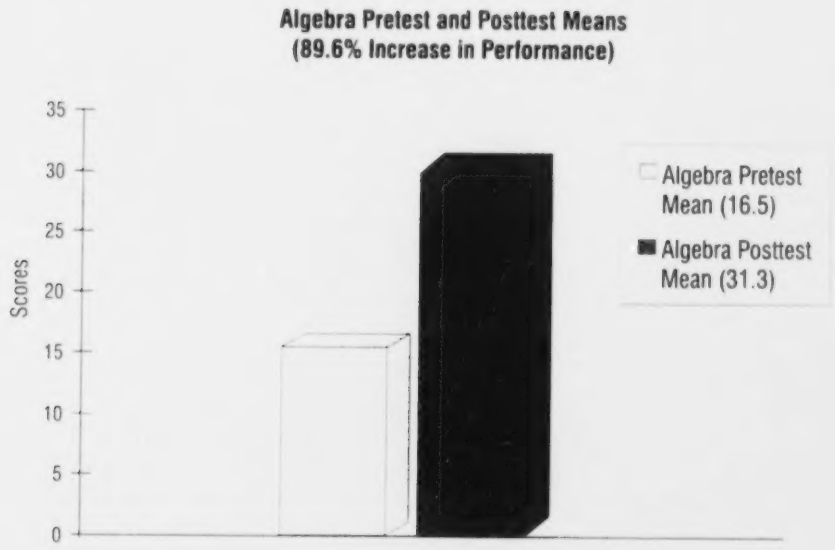

Figure 2a

Similarly, in Figure 2a, students' algebra pretest and posttest results were compared to determine if there was a significant difference between the mean scores. The results revealed that the algebra pretest mean was 16.5 compared to the algebra posttest mean of 31.3. This reflects an 89.6 percent (89.6%) increase in academic performance on the algebra posttest. The t-test performed on the algebra scores yielded a p-value of less than 0.05 ($p<0.05$). The alpha level was set at 0.05. This confirms that algebra students made significant academic progress.

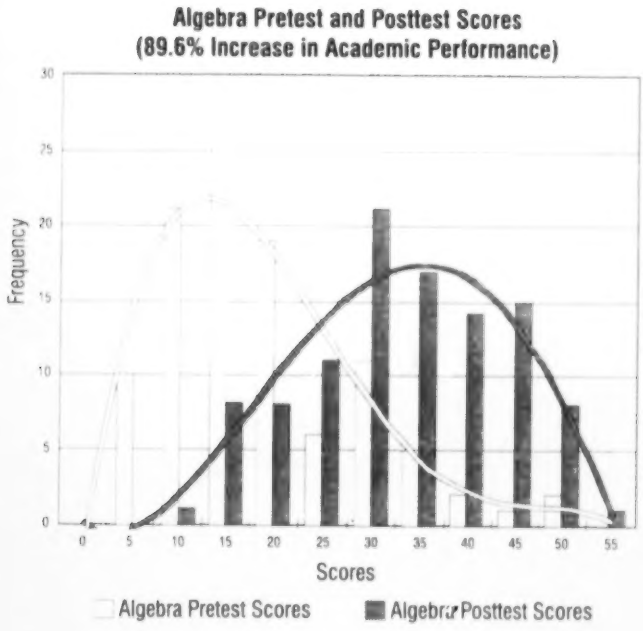

Figure 2b

In Figure 2b, the distribution of algebra pretest scores is skewed to the right, which shows a large range of student scores, with most students scoring in the lower groups. The posttest distribution of scores shifts more to the right, and is closer to a normal distribution. The distributions clearly indicate that a majority of the students had substantial increases in their scores.

Student Presurvey and Postsurvey Results

The data from the pre- and postsurveys from students reflected a wide range of attitudes about mathematics. Responses to the postsurvey showed eighty percent (80%) of the students completing the course had a positive experience with *Mathematics Foundations* (Figure 3). Seventy percent (70%) agreed that hands-on applications helped them understand mathematics better (Figure 4).

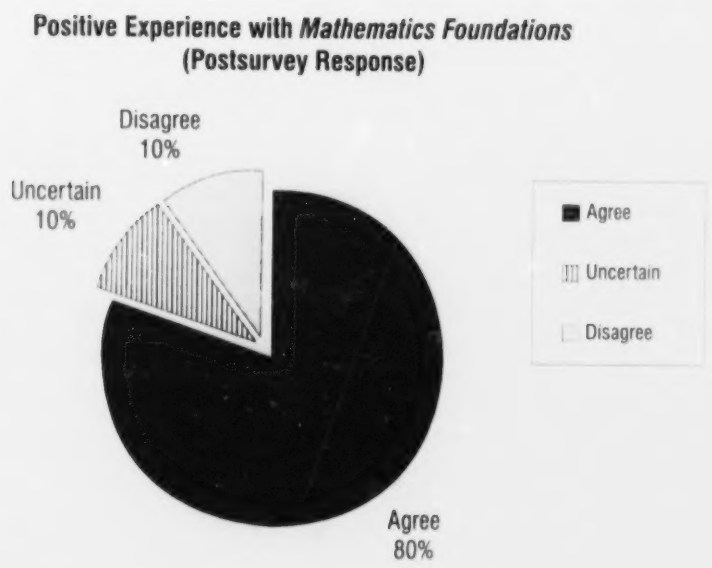

Figure 3

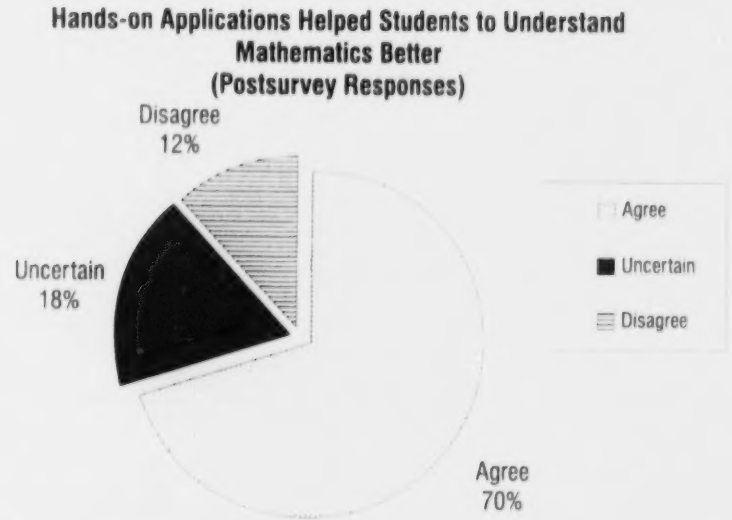

Figure 4

It was important to assess students' feelings about their mathematics ability. Accordingly, one presurvey question asked students to indicate why they thought they were taking a developmental mathematics course. As shown in Figure 5, the study revealed that eighty-nine percent (89%) of the students participating thought they were in developmental

mathematics courses because of poor mathematics skills or failure on college entrance exams. Seven percent (7%) indicated that they needed the course as a degree prerequisite, and four percent (4%) indicated they took the course because of a personal choice rather than a requirement. These findings are consistent with previous research that describes the reasons postsecondary students are placed into developmental mathematics courses (Austin; Lazdowski; Tinto; Zwerling).

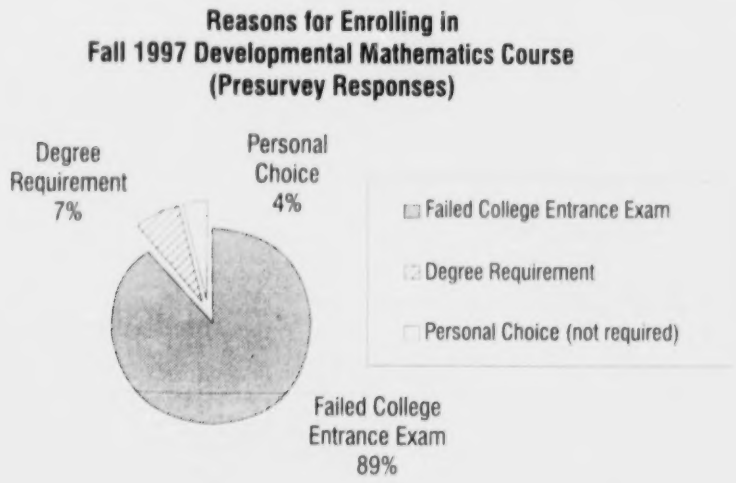

Figure 5

The following qualitative statements are examples of written responses from students explaining why they believed they needed a developmental mathematics course. These responses help identify students' own interpretation of their attitudes to and perceptions of their mathematics ability. These quotations have not been edited.

"I was out of school for one year, so this is where I was placed."

"The counselor said I had to take it probably because I did real bad on the placement test."

"Because they tell me I have to"

"Because I missed college level math by one point"

"I want to refresh my memory also to continue with my education."

"To improve my math skills and overcome past experiences"

"I need a strong and sound foundation in concepts to build confidence."

"I feel I hardly know the world of mathematics."

"To catch up in math since high school"

"Because I'm horrible in math"

"It's what they gave me."

"To learn different and easier methods to solve problems"

" ? "

"Because I'm weak in math"

"Learning disability"

Presurvey data indicated that of the 478 students who participated in the survey, only 51 students (11%) were not frustrated with their previous mathematics experience. However, after completing Mathematics Foundations, the number of students not frustrated increased to 132 (28%) as recorded by the postsurvey data. As shown in the right side of Figure 6, 183 students did not complete the postsurvey and were considered noncompleters. However, postsurvey data represent a retention rate of 62% in this course.

One could assume that some of these individuals would consider themselves frustrated. Even with that assumption, the number of frustrated mathematics students was reduced substantially.

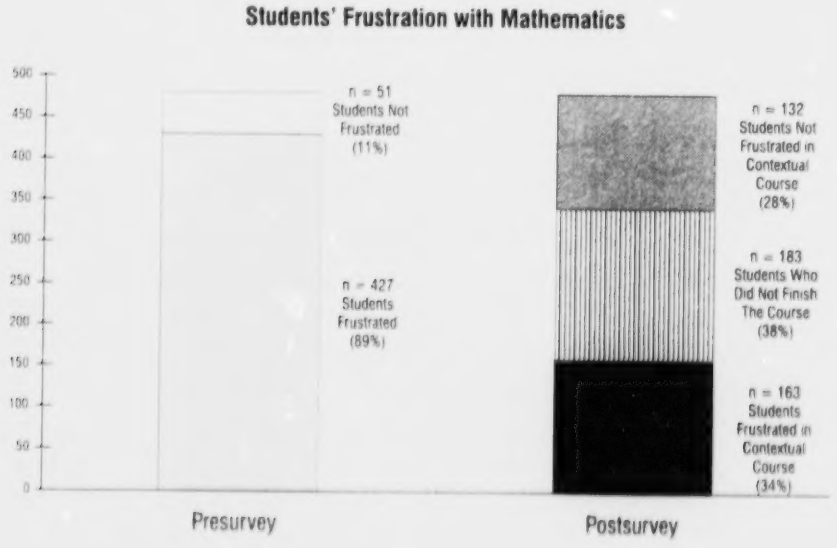

Figure 6

A presurvey question asked students to express what frustrated them in previous mathematics courses. The following responses reflected their beliefs:

"Old style of teaching – go to the board to do it – in high school"

"It was boring and the teachers never showed enthusiasm."

"When I couldn't catch on to an idea and sometimes applying it to real life situations"

"Almost all math – I can't grasp the concepts of it."

"I was always lost."

"The fast pace and bad instructors"

"I could not get the application process"

"Understanding the relationship of the numbers to real life"

"Inability to relate to every business"

When asked to respond to the postsurvey question to explain their satisfaction with their performance in the *Mathematics Foundations* course, students' responses included:

"A lot of these types of problems will help me with real life problems to solve at my job."

"I was confident in the assignments – didn't mind doing math problems."

"For the first time in my life I felt I accomplished many things in math."

"I have done better in this math course than what I have done in the past. I believe working in groups with other students helping out with each other let me understand better."

"I have had a very positive learning experience in this class. It has helped me to achieve a high level of self confidence in working math problems and taking tests."

"I really enjoyed how I was taught. No other teacher I had took the time to explain by hands on experience."

"I have never done well in math. After this semester I felt much more confident because my grades were much higher."

Since failure in mathematics has been linked to students' attitudes toward mathematics (Cox), it is not surprising that complementary research indicated that a "newfound success in mathematics in equal measure will enhance students' attitude about learning mathematics" (Arriola). Also, students' attitudes in mathematics are influenced by how teachers teach (Arriola). The survey responses in this study seem to be consistent with the findings of existing research.

More Confident About Solving Mathematics Problems (Postsurvey Responses)

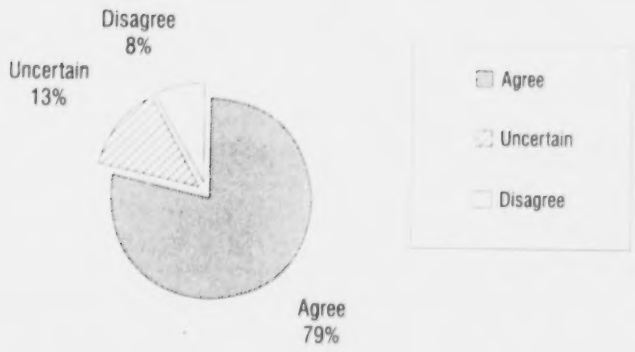

Figure 7

Students' attitude toward mathematics is enhanced by their ability to solve problems. In this study, seventy-nine percent (79%) of the students reported that they felt more confident about solving mathematics problems in this course than in previous mathematics courses (Figure 7).

Instructor Presurvey and Postsurvey Results

Instructors' frustration with teaching developmental mathematics courses

Instructors expressed a wide range of attitudes about their experience with teaching developmental mathematics. In the presurvey data, eighty-six percent (86%) of the participating instructors indicated that they were frustrated with teaching developmental mathematics prior to the study (Figure 8). This percentage is the total of the responses "sometimes" (79%) and "majority of the time" to the question of how frequently they were frustrated by teaching such courses (7%).

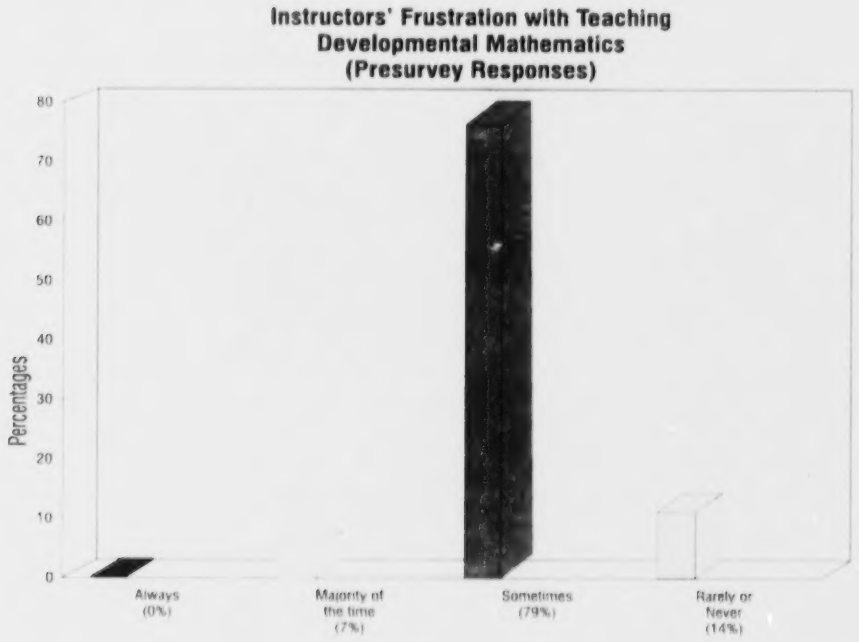

Figure 8

The following statements are examples of presurvey comments from instructors concerning their frustration with teaching developmental mathematics prior to teaching *Mathematics Foundations*:

"Students not doing the work"

"When students don't take any responsibility in their own learning"

"Student not attending class"

"The baggage that students bring with them (attitudes)"

"Motivating students and dealing with learning disabilities"

"Attrition rates and retention of concepts"

Instructors' satisfaction with teaching the *Mathematics Foundations* course

All of the instructors surveyed indicated that they enjoyed teaching mathematics from a contextual, hands-on perspective (Figure 9). Although instructors indicated some frustration with the *Mathematics Foundations* course, fifty-seven percent (57%) agreed that students gained greater understanding of mathematical concepts in this course. Most instructors who reported frustration related it to "lack of time to work through lab materials." Instructors who cited this particular difficulty also noted that they now had the experience they needed to better plan laboratory activities.

Furthermore, some instructors reported frustration with student behavior and interpersonal problems. For example, one instructor reported that "one group fell apart – argued/tears – I switched them to other groups with more interaction among students. There was more conflict." Another instructor said she became frustrated during the course because she believed that "this type of student needs rigid structure and organization in the classroom. I myself was unorganized, mainly because of not being familiar with the textbook and the lack of flow of the book." However, the same instructor further said she "strongly believed in contextual learning techniques and will continue to use them."

All instructors agreed that students gained a better understanding of mathematical concepts and the way they relate to real-life situations while using *Mathematics Foundations*. In addition, only twenty-eight percent (28%) of the instructors surveyed observed students who displayed math anxiety, apprehension, or intimidation with the course context and delivery.

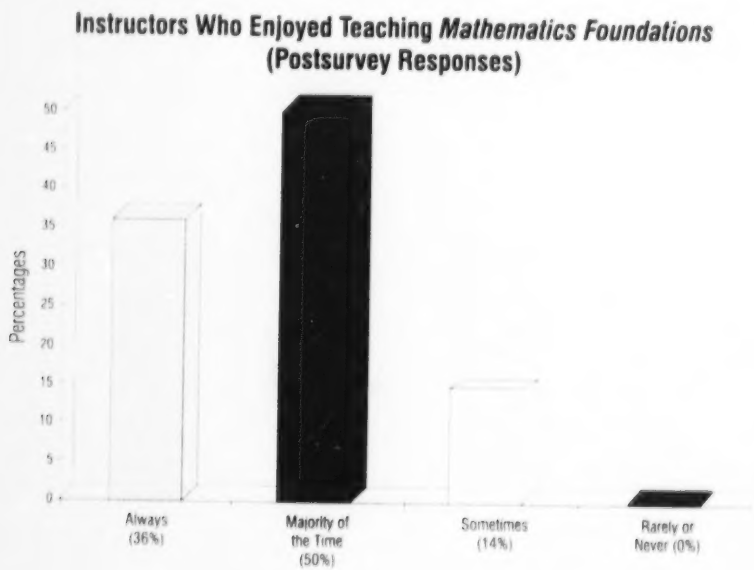

Figure 9

Instructors' opinions on the effectiveness of professional development

Sixty-four percent (64%) of the instructors attributed success in this course to the professional development and training they received prior to their implementation of the *Mathematics Foundations* course. Most instructors agreed that the training sessions were adequate in preparing them to teach from a contextual, hands-on perspective. One instructor said that the professional development workshop "took the anxiety away and provided a

support group of teachers relatively close by to contact." Another instructor not only felt that the training was adequate in preparing her to teach the course, but that "basic use of materials and labs was useful; however pacing and minor details of labs come with your own experience of using the materials. . ."

Instructors' responses

Fifty-eight percent (58%) of the instructors were pleased with their students' overall increase in academic performance and positive change in attitudes (Figure 10).

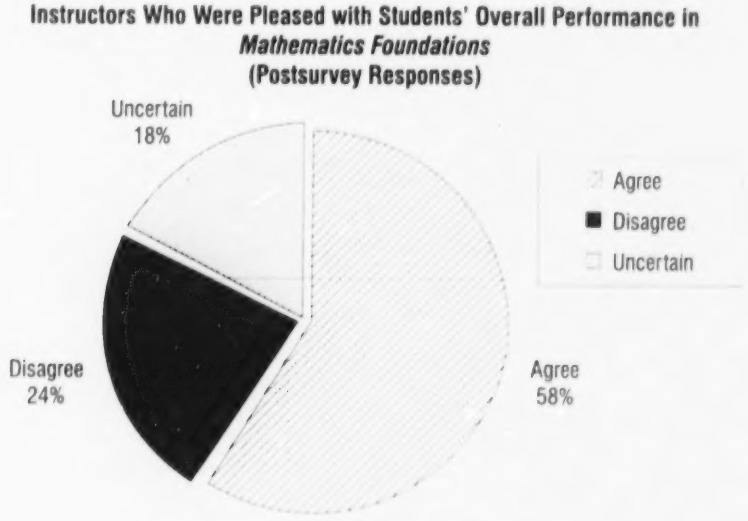

Figure 10

When specifically asked about the textbooks, thirty-three percent (33%) of the instructors said they liked the books without revisions. In response to a similar question, fifty-six percent (56%) said they would use them again in teaching the same course. Some instructors simply expressed their concern with what they believed the text lacked, while others offered suggestions for improving portions of the curriculum textbook. The following are samples of responses:

> "The text is lacking in some basic principles such as showing students how to do arithmetic by hand, rather than solely by using the calculator."
>
> "I have more confidence in their ability to do word problems, but they may be too dependent on calculators."

Despite these concerns expressed by instructors concerning *Mathematics Foundations*, the survey data revealed that sixty-two percent (62%) of the instructors would recommend the course to their colleagues. Only twenty-nine percent (29%) reported that they were

uncertain about the curriculum's effectiveness, citing issues such as needing additional time to complete the numerous lab activities in the textbook, and difficulty with the structural layout of the textbook. It is worth noting that suggested revisions to the textbooks were carefully reviewed during the fall 1997 semester and several changes in content and organization were made.

Instructors' opinions about contextual learning methods

Instructors provided the following written responses about their feelings and attitudes after completing the *Mathematics Foundations* course:

> "With a contextual learning approach, students do not ask 'when will I ever use this junk?'; they acquire ownership of mathematics."
>
> "I'm impressed with the concepts."
>
> "It was a challenge adapting to the textbook and interpreting the word problems, but I feel students were able to see uses of mathematics in the real world."
>
> "I was very pleased with the textbook's use of word problems. I feel my students will be better able to handle them in algebra because of the complexity and variety they were exposed to."

Course format

As regards course format, responses from instructors included the following:

> "I've been exhilarated by it."
>
> "I liked the combination of lecture, lab, and group [work], and especially incorporating the labs and real life contextual problems."
>
> "Loved the fundamental mathematics in every aspect"
>
> "I did enjoy teaching the course. The students seemed to try harder than other classes in the past."
>
> "I believe that the mathematics fundamentals course has a lot to offer at the postsecondary level."
>
> "The older students did understand mathematics concepts related to real life situations; the younger ones were unmoved."

Course delivery

On course delivery, instructor comments included the following:

> "Although there was a lot of griping about labs, a poll I took at the end of the semester indicated the students are overwhelmingly in favor of continuing the labs."

"I truly enjoyed teaching the course. The students seemed to be annoyed at first by working word problems, but by the end of the semester, they seemed to understand why they were doing this sort of real world application."

Data from Internet Listserv Comments and Telephone Conversations

Instructors' anecdotes

As mentioned previously, instructors participating in the pilot evaluation were included in an Internet listserv. This allowed instructors to communicate with both the professional development workshop facilitator and each other to ask questions or share experiences during the semester. Instructors without access to E-mail communicated via telephone. The following were examples of comments received via E-mail and by telephone from instructors:

"The first day of class a young man attended. He then missed the following 3 classes. Upon returning to the 5th class session, he participated in a lab activity. After the lab, he commented that he had never understood math before and he felt he could learn it this way. It made sense. He attended every day [after that]."

"During the first week of class an older female student was concerned about group work. She was placed with a group of strong personalities and was still concerned. I then placed her in another group where she became the leader. She loves it and said she never thought of herself as being a leader before."

"On the first test, the lowest grade was an 80, which is great."

"I have conquered the students' fear of mathematics by using the materials. Students are engaged [as] never before. I, as an instructor, knew I should be including activities as all the standards state. Now that they are right in the book, with clear directions, they are easy to include and easy to understand."

"I loved the way percents were taught in fundamental mathematics. It was so natural that the students didn't realize they were learning it. They got through it and went right on..."

About the window-washing lab activity:

> "The students were cleaning the windows in the building and the college president walked by. He stopped to ask me if the janitorial services were unacceptable. I discussed the lab activity, including the determination of the time taken per window, the contracted cost offered by NCC, the worker hiring criteria, etc. The president was very impressed with the lab and the student involvement. He told every administrator that day about the CORD materials and the activity."

Conclusions

Addressing the Need to Improve Mathematics Skills in Postsecondary Students

Developmental mathematics has become of great concern in postsecondary education. In our technical society with its high-performance workplaces, colleges are challenged to address vital issues. One of these issues is mathematics, which has been identified as a primary barrier to gaining employability skills and meeting career aspirations (Stage and Kloosterman, 1995). Postsecondary institutions must find more effective ways to help students succeed who are underprepared for college mathematics. However, in postsecondary developmental mathematics, few analyses exist of factors that relate to students' success in remedial college-level mathematics courses (Stage and Kloosterman, 1995).

Through previous theoretical research, we have learned that the theory of self-efficacy (Bandura, 1982) has linked an increase in students' positive attitudes about specific tasks to their increased academic performance of that task and vice versa. This research evaluation of *Mathematics Foundations* used the self-efficacy theory to examine the academic performance and attitudes of postsecondary developmental mathematics students and instructors. The one-semester evaluation confirmed many aspects related to the self-efficacy theory. Both students and instructors indicated evidence of self-efficacy (Bandura, 1982) primarily because of the students' increased academic performance and both students' and instructors' positive attitudes about learning and teaching a contextually based, hands-on curriculum like *Mathematics Foundations*.

From the analysis of student academic performance and the data collected in the attitudinal surveys, evidence emerged to answer the following research questions articulated in the study's rationale: Can students achieve increased academic performance on pre- and posttests? How does *Mathematics Foundations* influence the attitudes of students and their instructors?

The first conclusion is that seventy percent (70%) of the students who participated in the study indicated that the *Mathematics Foundations* curriculum seemed to help them understand mathematical concepts better than mathematics courses they had previously

taken. The second conclusion focuses on the pre- and posttest results: a twenty-six percent (26.2%) increase in academic performance in the fundamentals course and a ninety percent (90%) increase in student performance in the algebra course. Both fundamentals and algebra t-tests statistically showed a p-value of less than 0.05 ($p<0.05$) with the alpha level set at 0.05. This indicated that the increases in both the pre- and posttest results were significant. Finally, through quantitative and qualitative postsurvey data, the study found that teachers and students who had no prior experience with contextual learning concepts in mathematics not only seemed to enjoy their experience with the *Mathematics Foundations* curriculum, but significantly increased their ability to teach and learn mathematics. Since the completion of this study, the textbooks and other curriculum materials have been revised based on the pilot-site feedback.

Research Implications

CORD has gained valuable knowledge through the findings in this research evaluation of *Mathematics Foundation.* However, a number of implications for learning and teaching contextual mathematics are evident and should be addressed.

First, there is a need to conduct a longitudinal study with postsecondary mathematics students using the *Mathematics Foundations* curriculum. This study should consider the longer-term academic performance and retention and completion rates, as well as the curriculum's influence on career choice. The current study indicates that contextually based, hands-on mathematics curricula should be investigated more thoroughly as a method of delivering developmental mathematics at the college level. This study evaluates the use of *Mathematics Foundations* in only one set of circumstances. A research study should be conducted to determine if the success seen in this study can be replicated under different and controlled conditions.

Second, there is a need to investigate, both quantitatively and qualitatively, the relationships between attitudinal improvement in members of this student population and their academic success. Perhaps a qualitative case-study approach to examining student attitudinal improvement might reveal in-depth factors linked to student academic achievement in mathematics. The longitudinal study currently underway with some of the students who participated in this study will begin the process, but longitudinal studies need to be conducted with larger student samples over longer periods of time.

Third, other correlation studies should be conducted to determine the relationship between the teachers' attitude and enthusiasm for the contextual hands-on approach to developmental mathematics and student success. There are indications in this study that student success is closely tied to teachers' enthusiasm. If this is validated by further studies, a rationale would exist to investigate the extent of the effect of the professional development activity on teacher attitudes and thus on student success.

For too long, the poor mathematics attainment of many students entering college has been something institutions have been reluctant to acknowledge. Saddled with students who have a history of poor performance in mathematics, colleges have lacked the professional development strategies, the pedagogical approaches, and the instructional materials through which poorly performing students can become mathematical achievers at high levels. The *Mathematics Foundations* curriculum attacks the problem at its heart by addressing the diverse learning styles of students, and by meeting their motivational need to see the importance of the knowledge and skills they learn in the contexts of their lives, their work, and their hopes for self-improvement. Since mathematics and communication tend to be the passports to advanced technical learning and career opportunity, the importance of reversing the current negative situation would be hard to exaggerate. The *Mathematics Foundations* curriculum is making an important contribution to this essential effort.

The author of this study welcomes the interchange of ideas, and encourages others to conduct evaluation and research projects related to the effectiveness of contextually based, hands-on teaching strategies used in developmental mathematics for college students.

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